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(54) Foamed products

(57) Aqueous foams are provided comprising at least one acidic foamable protein, preferably whey protein isolate or bovine serum albumin, and a cationic polysaccharide, preferably chitosan or partially hydrolysed chitosan.

Enhanced tolerance to the presence of lipid is demonstrated, particularly in the presence of a water-soluble sugar such as sucrose.

The foams can be used to produce foamed culinary products such as meringues and cake mixes and they can be used for non culinary purposes such as aerated lubricants and fire extinguishing compositions.

GB 2 179 043 A

SPECIFICATION

Foamed products

The present invention relates to foamed products, preferably for use as foodstuffs.

Protein foams may be obtained by whipping an aqueous solution of a protein. The whipping process comprises agitating the solution in the presence of air so that a foam consisting of air cells surrounded by the solution is formed. The function of the protein in these foams is to form a cohesive film or skin around the air cells to prevent the foam collapsing when whipping is stopped. The solution may contain other constituents such as sugar. Such foams are used for a variety of culinary purposes, such as the making of meringues in which the protein foam containing sugar is baked to produce a mass of air cells enclosed by solid walls of protein and sugar. The protein solution is commonly obtained from white of egg but many other sources of protein may be used.

The foam-forming capacity of a protein solution, as measured by the increase in volume of the solution on whipping, and also the stability on standing of the foam depends in part on the identity of the protein used. For example a solution of egg albumen gives a reasonable degree of expansion on whipping and the foam formed may be stored for a considerable time before collapsing.

The expansion on whipping and stability of the foam are affected by other constituents dissolved or dispersed in the protein solution. For example the presence of sucrose may increase both expansion on whipping and foam stability but the presence of even small quantities of lipids such as vegetable oils and fats generally suppresses foam formation either partially or completely. It has therefore been difficult to provide a satisfactory protein foam containing oils or fats and when making a protein foam it has been essential to avoid contamination of the solution by lipids, including contamination by yolk of egg.

The proteins used in culinary applications are normally acidic proteins, that is they have isoelectric points less than 7. The acidic proteins include egg albumen, bovine serum albumin, bovine plasma, whey protein isolates and hydrolysed soya isolates, and are obtainable from a wide range of sources including milk, eggs, blood plasma, legumes, meat and microorganisms.

It is known from UK-A-2134117 and from J. Sci. Food Agric. 1984, *35*, 701–711 that protein – protein interactions are important in the foaming of heterogeneous protein systems. It has now been found that certain polysaccharides can also advantageously interact with the proteins of food products to yield improved foams.

Although edible polysaccharides, such as starches and dextrins, are known as whipping agent stabilizers in food products, their action in foams is dependent on their viscosity enhancing properties and not on physical interaction with proteins in the composition.

It has now been found that a polysaccharide having cationic properties is capable of interacting with the acidic proteins for example in food compositions to yield a relatively stable foamed product. Cationic polysaccharides occur naturally and one well-known edible example, which can be extracted from fungi, is chitosan.

Chitosan is a strongly cationic polysaccharide which can also be prepared by the alkali-catalysed deacetylation of chitin, a ubiquitous material found, for example, in crab shells, and prawn and insect cuticle. It is composed of repeating glucosamine subunits linked by β-1-4 glycosidic likages into a linear polymer analogus to cellulose. It has one primary amino group per subunit. Chitosan has a variable molecular weight distribution depending on the severity of the processing conditions, but typically lies in the range 100,000 to 1 million.

Chitosan is soluble in several aqueous organic acids, for example acetic or citric. Its main use in food processing is as a protein precipitant, for example as a wine fining or in the recovery of protein from effluent streams. This it does by combining with the negatively charged acidic proteins to form insoluble complexes at concentrations of from 10mg/1 to 200mg/1.

Chitosan is presently not used as a functional food ingredient, although its lipid-binding properties have been described in US-A-4223023.

We have found that, surprisingly and in contradiction to the known teaching about chitosan, chitosan is able to interact with proteins without precipitation to yield an enhanced foaming system, and furthermore that chitosan's tendency to cause protein precipitation can be suppressed by the addition of at least one sugar, particularly sucrose.

Cationic polysaccharides may also be prepared by the chemical modification of non-cationic polysaccharides; for example, positively-charged arginine residues may be attached to polygalacturonic acid using a carbodiimide as an activating agent.

Although most acidic proteins form a stable foam with cationic polysaccharides, there is one class of protein that appears not to be able to foam. These are those proteins such as sodium caseinate and gelatin which have a random elongate structure, rather than an ordered compact structure such as that of the so-called "globular" proteins. The term "foamable protein" is used herein to refer to the proteins that foam and to exclude the defined class of proteins which do not.

In accordance with the present invention there are further provided both edible and non-culinary products formed from an aqueous foam comprising at least one acidic protein and a cationic polysaccharide.

It will be appreciated that there are many different "chitosans" depending on the nature of the source of the basic chitin and on the processing conditions used. In particular, the deacetylated chitin can be subjected to various degrees of hydrolysis to lower the average molecular weight thereof. Improved foaming has been found

with hydrolysis products having a degree of hydrolysis of up to about 10%; that is with about 10% of the glycosidic bonds broken.

Furthermore, chemical modification of the deacetylated chitin is possible to enhance or suppress certain physical and chemical properties of the molecule. For example, chitosan's charge density can be increased by chemical modification of some of its hydroxyl groups.

Such hydrolysed and modified molecules are to be considered in this description to be within the meaning of the term "chitosan" if their foaming behaviour emulates deacetylated chitin.

The preferred concentration of the particular polysaccharide used is dependent on its identity and on the particular protein used, but is generally from 0.075 to 0.5w/v%, but could be higher. Similarly the weight ratio of protein to polysaccharide in the foam is variable, but is generally from 20:1 to 3:1, preferably from 10:1 to 6:1, with a total protein concentration of less than 10w/v%, preferably about 6w/v%.

Enhanced foaming has been found to occur within a pH range of from 5.0 to 7.5, preferably from 5.3 to 6, with a sucrose concentration of at least 10w/v%, preferably from 20w/v% to 30w/v%.

Surprisingly, it has been found that the foam enhancing ability of the polysaccharide is not destroyed by the presence of a lipid, but that up to 30w/v% of, for example, corn oil can be tolerated, provided that the concentration of polysaccharide (and therefore of protein) and of sucrose is not too low. Too much lipid will, of course, result in over-stressing and consequent break-down of the foam system.

In addition to sucrose, other water-soluble sugars, including glucose syrup, have been found to enhance foaming and to improve foam stability.

A wide variety of food products can be thus obtained both directly from and by heating the foam of this invention.

The present invention will now be described by way of example with reference to the following experimental results:–

In the following Examples, solutions in water containing the dissolved constituents given in the Tables were whipped at ambient temperature for 5 minutes in a food mixer (Kenwood Chef Model A 901) operated at 200 revolutions per minute. The initial volume of the solution before whipping and the volume of the foam produced immediately after whipping were measured. The foam was then allowed to stand undisturbed for 30 minutes at ambient temperature and the volume of liquid which had drained from the foam was measured, and the foam volume re-measured.

The % foam expansion (FE), % foam volume stability (FVS), and % foam liquid stability (FLS) were calculated as follows:

$$FE = \frac{\text{(Initial volume of foam including liquid} - \text{Initial liquid volume)}}{\text{Initial liquid volume}} \times 100$$

$$FVS = \frac{\text{(Final foam volume)}}{\text{Initial foam volume including liquid}} \times 100$$

$$FLS = \frac{\text{(Initial liquid volume} - \text{volume of liquid drained)}}{\text{Initial liquid volume}} \times 100$$

For the solutions tested in Comparative Examples A and B and in Examples 1 to 23, the general method of preparation was as follows:–

Chitosan (No.C3646, obtained from Sigma Chemical Co.) was dissolved at a level of 0.5% in 0.5% acetic acid.

The chitosan dissolved after about 1.5 hours. Protein solutions were prepared independently, and then mixed, except when 0.4% chitosan was required. Then the protein was dissolved directly in the chitosan solution. The pH value was adjusted using either 5M or 1M sodium hydroxide and hydrochloric acid.

In each case 250 ml of solution were tested and where "oil" was added the oil used was corn oil, unless otherwise specified.

In general in the tabulated results of the Examples, the protein, polysaccharide and sucrose concentrations are expressed as percentages of the total volume of the solution tested on a weight per volume basis. For the oil, the concentrations given are on a percentage volume per volume basis and are the amounts of oil added to the solution to be tested. The Comments are the Inventor's subjective observations on the appearance of the solution immediately after mixing and on any foam produced thereby.

Comparative Examples A and B

For comparative purposes, two test solutions were prepared using bovine serum albumin (BSA) and a whey protein isolate (WPI) without any chitosan being present. The results appear in Table 1, Example A being for BSA and example B being for WPI.

TABLE 1

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
A	1.0	0.0	0.0	10	6.0	50	0	0	Practically no foam
B	1.0	0.0	10	0	6.0	180	65	5	poor

Since BSA is on its own quite easily foamed, some oil was added in Comparative Example A to demonstrate more clearly the effect of chitosan. Oil addition was not necessary for WPI.

Examples 1 to 5

The importance of pH was examined using BSA as the protein source, and the results appear in Table 2

TABLE 2

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
1	1.0	0.1	0.0	10	4.0	30	0	0	practically no foam
2	1.0	0.1	0.0	10	5.0	130	35	10	flowy
3	1.0	0.1	0.0	10	6.0	380	85	30	stiff foam
4	1.0	0.1	0.0	10	6.5	200	70	10	flowy
5	1.0	0.1	0.0	10	7.0	100	40	10	poor

Although some foam expansion was obtained both at pH 4.0 and at pH 7.0, it is clear that for optimum foaming there is a preferred pH, which in the case of BSA, in the absence of sucrose, is about 6.0.

Examples 6 to 8

The effect of varying amounts of sucrose on the foaming behaviour of chitosan/protein solutions is shown in Table 3.

TABLE 3

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
6	1.0	0.1	10	10	6.0	530	95	70	very stiff
7	1.0	0.1	20	10	6.0	700	100	80	very stiff
8	1.0	0.1	50	10	6.0	540	100	100	extremely stiff

It will be noted that the general trend is for superior foams to be produced with increasing levels of sucrose. However, with large amounts of sucrose the foam expansion tends to be reduced, presumably because of the increasing weight per unit volume of the foam. About 20% sucrose appears to yield optimum foaming behaviour.

Examples 9 to 12

The tolerance of the BSA/chitosan foaming system to the presence of lipid is demonstrated in Table 4 (also see Example 7).

TABLE 4

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
9	1.0	0.1	20	20	6.0	540	100	95	very stiff
10	1.0	0.1	20	30	6.0	340	90	50	fairly stiff
11	1.0	0.1	50	30	6.0	45	45	20	very poor
12	4.0	0.4	50	30	6.0	430	100	100	very thick stiff

By using sucrose at what appears to be an optimum concentration, quite high concentrations of lipid can be tolerated.

Examples 13 to 16

Using BSA as the protein source, the optimum ratio is protein to chitosan was sought, and the results are shown in Table 5.

TABLE 5

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
13	1.0	0.05	20	10	6.0	130	65	20	poor
14	1.0	0.1	20	10	6.0	700	100	80	very stiff
15	1.0	0.2	20	10	6.0	660	100	90	very stiff
16	1.0	0.33	20	10	6.0	200	70	10	poor

These results suggest that about a 10:1 protein/chitosan ratio is usually suitable.

Examples 17 to 19

The WPI/chitosan system's tolerance of lipid was tested, but was found – for the particular samples tested – to be markedly less than for BSA as Table 6 shows.

TABLE 6

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
17	1.0	0.1	10	0	6.0	780	100	90	very stiff
18	1.0	0.1	10	1.0	6.0	480	85	40	stiff
19	4.0	0.4	10	10	6.0	40	0	0	very poor precipitated a lot

An attempt to make the WPI/chitosan system tolerant of the presence of 10% corn oil by increasing the concentration of chitosan – and consequently of WPI in order to maintain the optimum protein/chitosan ratio – lead to break-down of the foaming system due to precipitation of the protein out of solution by the chitosan. It is postulated that an increase in the sucrose concentration could assist foam stability despite the presence of corn oil at the 10% level.

Examples 20 and 21

The effect of altering the pH of the solution for WPI is markedly demonstrated in Table 7. (It should be noted that these results were obtained at sub-optimum chitosan/protein ratios).

TABLE 7

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
20	4.0	0.1	10	10	6.0	40	0	0	very poor precipitated a lot
21	4.0	0.1	10	10	5.3	220	80	20	moderate. Milky solution

The optimum pH for WPI appears to be slightly lower than for BSA. These results suggest that for each type of protein used – and possibly each protein extraction method used – there is an optimum pH for foaming with chitosan.

Examples 22 and 23

Taken together with the results of Examples 20 and 21, the results set out in Table 8 show how the selection of pH is also important in the avoidance of precipitation, despite quite high levels of chitosan.

TABLE 8

Ex	protein	chitosan	sucrose	oil	pH	FE	FVS	FLS	Comments
22	4.0	0.2	10	10	5.3	280	90	60	moderate. Milky solution
23	4.0	0.4	10	10	5.3	780	100	100	extremely stiff

In the following Examples 24 to 107 two types of chitosan were used; a native chitosan (chitosan N) and a slightly hydrolysed derivative (chitosan SH), both supplied by Protan Laboratories, Inc. Redmond, Washington, U.S.A. A comparison of their properties is set out in Table 9. the sample of native chitosan was used for the preparation of samples of varying degrees of hydrolysis. Chitosan SH was used in most of Examples 24 to 107 in preferance to the chitosan N because its viscosity was low enough to facilitate mixing, and its solubility characteristics were better. It also showed a markedly decreased tendency to precipitate acidic proteins out of solution. The molecular weight could not be measured accurately because chitosan is heterodisperse; that is, it contains a wide range of molecular weights. However, the material can be defined accurately in terms of its viscosity (see Table 9) or degree of hydrolysis (percentage of glycosidic bonds cleaved).

TABLE 9

Property	*Native chitosan (chitosan N)*	*Slightly hydrolysed chitosan (chitosan SH)*
Viscosity (1% in 1% acetic acid)	585 cps	25 cps
%ash	1.0	0.61
%deacetylation	8.47	88.3
%moisture	12.0	13

In Examples 24 to 107 the following variable were studied:–

	Examples
a) Total concentration of protein + chitosan	24–27
b) Effect of homogenisation prior to aeration	28–29
c) Ratio of chitosan to protein	30–35
d) pH	36–45
e) Sugar concentration	46–55
f) Type of acidic protein	56
g) Salt (sodium chloride) concentration	57–64
h) Type of fat/oil	65–78
i) Temperature	79–82
j) Effects of sugars and related compounds	83–92
k) Effect of degree of hydrolysis of chitosan.	93–107

The results are tabulated in Tables 10 to 20/21, respectively.

Examples 24 to 27

The influence of total concentration of protein and chitosan SH was assessed using a whey protein isolate (WPI)

A WPI/chitosan ratio of 10:1 by weight was maintained and the WPI concentration varied from 2–8% by weight to establish the optimum. Sucrose and corn oil concentrations were fixed at 10% by weight and the pH at 6.0. The results appear in Table 10.

TABLE 10

Ex.	*%Protein (WPI)*	*%Chitosan SH*	*FE%*	*FVS%*	*FLS%*	*Comments*
24	2.0	0.2	140	60	10	poor
25	4.0	0.4	500	95	75	moderately stiff
26	6.0	0.6	550	100	90	stiff
27	8.0	0.8	—	—	—	formed dense aggregate which could not be whipped

The results suggest that 6% by weight is the optimum protein concentration in the case of WPI.

With BSA and chitosan N (see Example 6) a comparable foam was obtained at a protein concentration of only 1% by weight. Therefore, although WPI is effective, it is not as good as BSA.

Examples 28 and 29

An experiment was carried out to establish whether emulsification of the oil with the protein solution prior to the addition of chitosan and adjustment of pH improved foaming properties. The solution used contained by weight whey protein isolate (6%), chitosan SH (0.6%) sucrose (10%) and corn oil (10%) at pH 6.0. In general the results were more consistent after emulsification and the solutions were less turbid. Foam expansion was increased (as shown in Table 11) and the foam texture was better. This method was therefore used for all subsequent whipping tests as the preferred method.

TABLE 11

Ex.	*Treatment*	*FE%*	*FVS%*	*FLS%*	*Comments*
28	none	550	100	90	stiff
29	emulsified	590	100	90	stiff

Examples 30 to 35

The protein concentration was fixed at 6% by weight and the concentration of chitosan SH varied. The results in Table 12 show that a ratio of 0.7 to 6 gave the best results. The mixture needed no pH adjustment which is

advantageous for technical reasons. Foaming was poor at ratios below 1 to 10.

TABLE 12

Ex.	*%Chitosan SH*	*FE%*	*FVS%*	*FLS%*	*Comments*
30	0.1	140	65	15	poor
31	0.2	100	60	20	poor
32	0.4	100	60	20	poor
33	0.6	550	100	90	fairly stiff
34	0.7	560	100	95	very stiff
35	0.8	560	100	95	very stiff

This optimum ratio compares closely with the ratio found for a different system using chitosan N and BSA as described in Examples 13 to 16.

In the subsequent Examples the phrase "optimum system" is used to refer to a solution containing the following in weight percent: WPI 6%, chitosan SH 0.7%, sucrose 10%, and corn oil 10%.

Examples 36 to 45

The influence of pH was tested using the "optimum system". Controls without chitosan (labelled "—") were tested. The results in Table 13 show that pH 6 gave the best results. This is consistent with theory since the two species will only be oppositely charged and therefore able to interact above pH 5.3 (the isoelectric point of WPI). At pH 6.5, the interactions may be too strong, resulting in the formation of insoluble precipitates.

TABLE 13

Ex.	*pH*	*Chitosan SH*	*FE%*	*FVS%*	*FLS%*	*Comments*
36	4.5	+	75	50	10	poor
37	4.5	–	120	55	0	poor
38	5.0	+	100	60	20	poor
39	5.0	–	170	65	10	poor
40	5.5	+	280	100	95	fairly stiff
41	5.5	–	195	70	10	poor
42	6.0	+	560	100	95	very stiff
43	6.0	–	160	60	5	poor
44	6.5	+	90	60	25	poor
45	6.5	–	155	60	0	poor

The effect of pH with more-extensively hydrolysed chitosan is considered in subsequent Examples. The results of Table 13 are similar to those obtained with chitosan N and WPI (see Examples 20 and 21) and BSA (see Examples 1–5).

Examples 46 to 55

The "optimum system" was used to assess the effect of different levels of sucrose. Table 14 shows that all foam parameters improved with sucrose concentration, and completely stable foams were obtained at 20% sucrose and above. Sucrose had no effect in the absence of chitosan. The level of sucrose used in subsequent Examples was 30% by weight.

TABLE 14

Ex.	*Sucrose concentration (% w/v)*	*Chitosan SH*	*FE%*	*FVS%*	*FLS%*	*Comments*
46	10	+	560	100	95	very stiff
47	10	–	160	60	5	poor
48	20	+	565	100	100	very stiff
49	20	–	130	55	0	poor
50	30	+	650	100	100	very stiff
51	30	–	115	55	0	poor
52	40	+	640	100	100	very stiff
53	40	–	125	55	0	poor
54	60	+	615	100	100	very stiff
55	60	–	110	55	0	poor

Similar results were obtained with chitosan N and BSA as shown in Examples 6–8.

Example 56

Bovine serum albumin and whey protein isolate are typical examples of soluble globular acidic proteins which work effectively in combination with chitosan under suitable conditions. A hydrolysed wheat protein ("Hyfoama") also gave good results as shown in Table 15.

TABLE 15

Ex.	*FE%*	*FVS%*	*FLS%*	*Comments*
56	570	90	30	moderately stiff

However, sodium caseinate and gelatin gave poor results. These are examples of protein molecules having a random elongate structure and they seem to be unable to interact in the controlled manner necessary.

Examples 57 to 64

The effect of sodium chloride concentration was tested with the "optimum system". Sodium chloride solution was added after mixing of other ingredients.

Table 16 shows that foaming is impaired only slightly by the salt concentrations likely to be found in foods. The foam became softer in texture as the salt concentration was increased.

TABLE 16

Ex.	*Molarity of sodium chloride*	*Chitosan SH*	*FE%*	*FVS%*	*FLS%*	*Comments*
57	0	+	650	100	100	very stiff
58	0	–	115	55	0	poor
59	0.05	+	430	100	100	very stiff
60	0.05	–	120	55	0	poor
61	0.20	+	520	100	100	stiff
62	0.20	–	230	55	0	poor
63	0.40	+	540	100	100	fairly stiff
64	0.40	–	120	55	0	poor

Examples 65 to 78

Many different types of fats are used in foods and a representative range was tested, using the "optimum system", except that 20% by weight fat was used unless indicated otherwise. As Table 17 shows good results were obtained with all fats apart from lecithin, which is known to be particularly detrimental to foaming.

TABLE 17

Ex.	*Type of fat/oil*	*Chitosan*	*FE%*	*FVS%*	*FLS%*	*Comments*
65	corn oil	+	570	100	100	very stiff
66	corn oil	–	130	55	0	poor
67	coconut oil	+	870	100	100	stiff
68	coconut oil	–	80	45	0	poor
69	butter oil	+	910	100	75	fairly stiff
70	butter oil	–	130	50	0	poor
71	cocoa butter	+	630	100	100	fairly stiff
72	cocoa butter	–	95	45	0	poor
73	lard	+	300	85	35	poor
74	lard	–	90	45	0	poor
75	lecithin (0.1%)	+	170	70	20	poor
76	lecithin (0.1%)	–	200	65	0	poor
77	lard (10%)	+	970	90	100	very stiff
78	lard (10%)	–	90	45	0	poor

Examples 79 to 82

In food processing, mixes are often aerated at chill temperatures. The effect of foaming at these temperatures was assessed for the chitosan SH/WPI system. The results in Table 18 show that reducing the temperature had little effect on foaming of the "optimum system" with 20% by weight fat.

TABLE 18

Ex.	Fat/temperature	FE%	FVS%	FLS%	Comments
79	Corn oil 7°C	570	100	100	stiff
80	Corn oil 25°C	570	100	100	very stiff
81	Coconut oil 7°C	830	100	100	very stiff
82	Coconut oil 25°C	870	100	100	stiff

Examples 83 to 92

Various sugars and polysaccharides are used in foods to sweeten them or to affect their texture. A representative range of "sugars" was tested with the "optimum system" of chitosan SH and WPI, with 10% corn oil and with the "sugar" under test at 30% by weight (except where indicated). Table 19 shows that good foams were obtained with sucrose, sorbitol, glucose syrup (42 Dextrose Equivalent) and polydextrose, but that methyl cellulose prevented foaming.

TABLE 19

Ex.	Saccharide	Chitosan	FE%	FVS%	FLS%	Comments
83	Sucrose	+	720	100	100	fairly stiff
84	Sucrose	−	115	55	0	poor
85	Sorbitol	+	900	100	100	stiff
86	Sorbitol	−	100	50	0	poor
87	Glucose syrup (42 DE)	+	770	100	100	stiff
88	Glucose syrup (42 DE)	−	100	50	0	poor
89	Polydextrose	+	930	100	100	very stiff
90	Polydextrose	−	100	50	0	poor
91	Methyl cellulose (0.1%)	+	270	60	0	poor
92	Methyl cellulose (0.1%)	−	100	50	0	poor

Examples 93 to 107

Chitosan N was hydrolysed to varying degree of hydrolysis ("DH") values by the addition of sodium nitrite. It is known that sodium nitrite deaminates chitosan and causes breakage of the glycosidic bond at the point of deamination. The number of glycosidic bonds broken is reported to be equivalent to the number of moles of sodium nitrite added. Chitosan samples were prepared having 5, 10, 15 and 20% of the glycosidic bonds cleaved, with correspondingly lower molecular weight distributions. The following composition was used to test the foam-enhancing properties of chitosan at various pH values: WPI = 6%; chitosan = 0.7%; sucrose = 30%; corn oil = 10%. Table 20 shows that chitosan with a DH of 5% showed a wider pH range of foaming compared to unhydrolysed chitosan or chitosan hydrolysed to a DH of 10%. Good foams were obtained at pH 7; 1 pH unit higher than unhydrolysed. Thus moderate hydrolysis improves the overall foam-enhancing properties. Hydrolysis beyond 10% yielded samples of poor foam enhancing power.

TABLE 20

a) Foam expansion (FE%)

		pH						
Ex.	Degree of hydrolysis of chitosan/%	4.5	5.0	5.5	6.0	6.5	7.0	7.5
93	0	80	100	280	550	90	—	80
94	5	—	—	190	720	780	830	250
95	10	—	—	230	470	700	520	230
96	15	—	—	—	350	—	—	—
97	20	—	—	—	480	—	—	—

b) Foam liquid stability (FLS%)

98	0	10	20	95	95	25	—	40
99	5	—	—	20	100	100	100	20
100	10	—	—	20	90	100	90	20
101	15	—	—	—	65	—	—	—
102	20	—	—	—	75	—	—	—

Table 21 shows that with BSA (2%), chitosan hydrolysed to DH values of 5 and 10% was still effective at the 0.2% level at pH 6.0. However DH 15% and DH 20% chitosan was not very effective. The composition used was chitosan N with BSA 2%, corn oil 10%, and sucrose 10% at a pH of 6.0.

TABLE 21

Ex.	*Degree of hydrolysis of chitosan/%*	*FE%*	*FVS%*	*FLS%*	*Comments*
103	0	770	100	90	stiff
104	5	770	95	75	fairly stiff
105	10	550	95	50	runny
106	15	300	80	15	poor
107	20	175	10	70	poor

The solutions described above may be foamed in order to produce foamed culinary products of kinds which are already known, such as meringues, cake mixes and batters. They may also be used in aerated food products which contain lipids, such as low calorie dietary foods, which have not hitherto been made by a foaming process. Foams made from the protein solutions may also be used for non-culinary purposes, for example as aerated lubicants and fire-extinguishing compositions.

CLAIMS

1. An aqueous foam comprising at least one acidic foamable (as defined) protein and a cationic polysaccharide.
2. A foam as claimed in claim 1 wherein the concentration of the polysaccharide in the foam is from 0.075 to 0.3w/v%.
3. A foam as claimed in claim 2 wherein the concentration of the polysaccharide in the foam is about 0.1w/v%.
4. A foam as claimed in any one of the preceding claims wherein the weight ratio of protein to polysaccharide in the foam is from 20:1 to 3:1.
5. A foam as claimed in claim 4 wherein the weight ratio of protein to polysaccharide in the foam is from 10:1 to 6:1.
6. A foam as claimed in any one of the preceding claims wherein the protein concentration in the foam is less than 10w/v%.
7. A foam as claimed in claim 6 wherein the protein concentration in the foam is about 6w/v%.
8. A foam as claimed in any one of the preceding claims wherein the protein is edible.
9. A foam as claimed in claim 8 wherein the protein is a whey protein isolate.
10. A foam as claimed in any one of the preceding claims wherein the pH of the foam is from 5.0 to 7.5.
11. A foam as claimed in claim 10 wherein the pH of the foam is from 5.3 to 6.
12. A foam as claimed in any one of the preceding claims wherein the polysaccharide is partially hydrolysed.
13. A foam as claimed in claim 12 wherein the hydrolysed polysaccharide has a degree of hydrolysing of from 5% to 10%.
14. A foam as claimed in any one of the preceding claims in which the polysaccharide is edible.
15. A foam as claimed in claim 14 wherein the polysaccharide is chitosan.
16. A foam as claimed in any one of claims 1 to 14 wherein the polysaccharide is a cationic derivative of a non-cationic polysaccharide.
17. A foam as claimed in any one of the preceding claims further comprising a water soluble sugar in an amount of at least 10w/v%.
18. A foam as claimed in claim 17 comprising a soluble sugar in an amount of from 20 to 30w/v%.
19. A foam as claimed in claim 17 or claim 18 in which the sugar is sucrose.
20. A foam as claimed in any one of the preceding claims wherein up to 30w/v% of a lipid is additionally present.
21. A foam as claimed in claim 20 wherein the lipid is corn oil.
22. An edible product consisting of or comprising a foam as claimed in any one of the preceding claims.
23. An edible product obtained by heating a foam as claimed in any one of claims 1 to 21.
24. A non-culinary product consisting of or comprising a foam as claimed in any one of the preceding claims.

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